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EVERY DAY

MARCH 15, 1919

SERIAL NO. 175

THE MENTOR

THE STORY OF
IRON and STEEL

By C. F. TALMAN
Editorial Writer
for The Scientific American

DEPARTMENT OF
SCIENCE

VOLUME 7
NUMBER 3

TWENTY CENTS A COPY

Wanted—A Song of Steel



WHO is the man that will write the Song of Steel? Perhaps it has been written and we have not seen it. We have searched for it in literature. If anyone has found it, tell us about it, for that is what The Mentor wants—an inspiring utterance in celebration of steel. Iron has held title as a hard and durable metal in the affairs of man since the Age of Iron. It has been the word, in the language of man, that stood for stern strength; "The Iron Hand," "The Iron Heart," "The Rod of Iron," "The Iron Rule" that crushes freedom, "The Iron Cross" for cruel achievement.



But long ago, in the practical and constructive work of man, iron was found to be too soft. Under pressure, iron yielded; under heat, it melted. Cast-iron snapped; forged iron bent. Put to the test, under the most exacting conditions, iron was heavy, unwieldy, and often gave way. Something more durable and reliable, more resistant under the wear and tear of service, more efficient in execution, was needed—and so, man made steel. Steel is iron with temper—and the temper of steel subdues iron. Steel blades cut iron sheets, steel shells puncture iron plates. The only metal that can answer steel is steel itself. Harder and more enduring than iron, steel possesses the additional advantage of flexibility, and the virtue of reliability. "True as steel" is the expression that confers the supreme title of dependableness on things material and on the character of man.



In the great World War nations opposed each other in terms of steel. The tiny needle of steel carried on the endless work of small sewing; the instrument of steel served the surgeon; vessels of steel transported troops and provisions and policed the sea; the steel helmet protected the man in the trenches; and the shrieking steel shell carried destruction to the enemy. It has been a War of Steel. And, in the work of reconstructing the affairs of man, steel will play a ruling part. Where steel has destroyed, steel will renew. Steel will extend our roads of transportation and form vast bridges. Steel will plow the shell-torn fields and reopen the soil for seed. Steel will support the construction of new buildings and will supply machines and instruments for renewed manufacturing activities. Steel will deliver and protect the necessary supplies of man. Steel is the metal that gives strength and stability to the industries of the world, as gold determines the standards of value. Who will sing the Song of Steel?

W. D. M.

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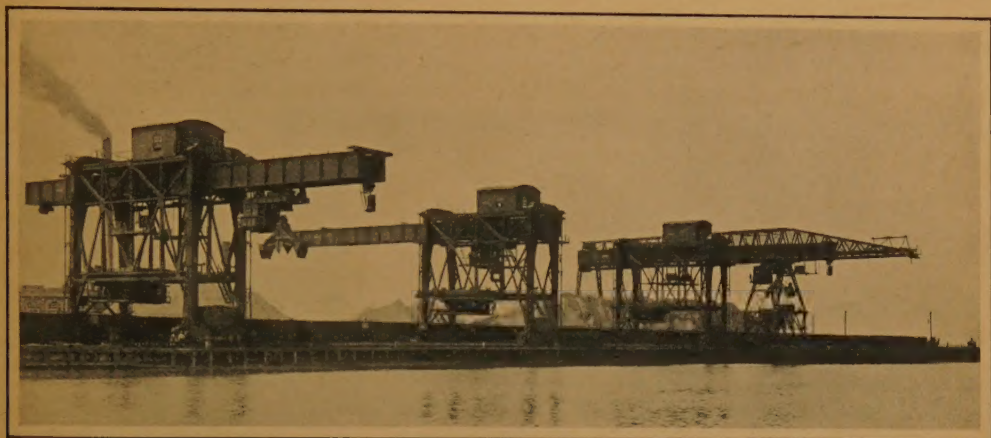
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Courtesy of Brown Hoisting Machinery Co.

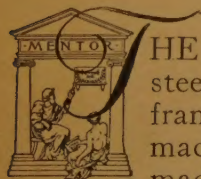
BROWN HOIST ORE-HANDLING EQUIPMENT, LORAIN, OHIO

The Story of Iron and Steel

By CHARLES FITZHUGH TALMAN

Editorial Writer for The Scientific American

MENTOR GRAVURES—LOADING IRON ORE INTO STEAMER • UNLOADING SCRAP STEEL WITH A LIFTING MAGNET • MODERN BLAST FURNACES AND ORE STOCK YARD • BESSEMER CONVERTER BLOWING • OPEN-HEARTH FURNACES • ROLLING A STEEL RAIL



THE iron and steel industry, which provides us with iron and steel ships, steel rails and steel trains to run upon them, steel-framed skyscrapers, implements in endless number, and the machinery with which almost all manufactured articles are made, is the backbone of our material civilization; but it is more than that. It is a latter-day miracle, quite as captivating to the imagination as any episode out of the Arabian Nights. It is the concrete expression of stupendous ideas.

The workshops of this industry are invested with the spirit of romance. They are capable of inspiring a species of awe and admiration quite akin to that which one feels in the presence of the Parthenon or the Pyramid of Cheops or a Gothic cathedral. Since the industry has reached its culminating point in America, this emotional aspect of it is something Americans should bear in mind. Our country is poor in many of the things that appeal to the spirit. Our very landscapes sometimes lack a certain touch of grace that is found in Europe. The fine arts do not always find a fruitful soil among us, and, above all, the art of living is often neglected by us in favor of the unlovely business of *making* a living.

THE STORY OF IRON AND STEEL

Nevertheless, whoever goes about the world in quest of emotions will find abundant store of them in America. It is a fair contention that one of our great steel plants, with all its noise, grime and odors, is as impressive a monument as St. Peter's in Rome or the Taj Mahal. It is impressive and it is uplifting, because it reminds us that almost no bounds may be set to the achievements of human ingenuity. Our subject is vast and many-sided. In the present brief sketch we can do no more than set down a few cardinal facts.

The Ore and the Mine

Pure iron is rarely found in nature and is not used in the arts. Iron combined chemically with other substances is the commonest of all metals except aluminum. The iron and steel of everyday use always contain various foreign substances. Many of these are easily seen with the microscope in a section of the metal, properly prepared. The microscopic and photographic study of such sections is called *metallography*, and it has cleared up, in large measure, the question why different kinds of steel and iron have such very different properties. A section of cast-iron, for example, shows plainly the particles of soft graphite which break up the structure of the iron and make it brittle.

The important iron ores are chemical compounds of iron and oxygen, with or without other substances. Mixed with the ore proper there is generally a certain amount of rock or earthy matter, known as the *gangue*.

About eighty-five per cent of the iron mined in this country comes from a comparatively small region of northern Minnesota, Wisconsin and Michigan, in the neighborhood of Lake Superior. In this region there are six *iron ranges*—definite tracts of iron-bearing land—from which nearly sixty-four million tons of ore have been taken in a single year. Their names are Marquette, Menominee, Gogebic, Vermilion, Mesabi and Cuyuna.

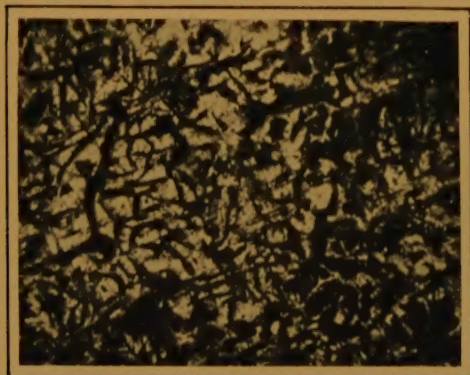
The Mesabi Range (variously known as Mesaba, Missabe, etc.) is the wonder of the iron-mining world. On the other ranges the ore is



Courtesy U. S. Bureau of Mines

SAFETY IN IRON MAKING

Blast house man wearing leggins, goggles, flat hat and woolen shirt. The Bureau of Mines has devoted much attention to devising safety measures in all branches of the iron and steel industry



From "Non-technical Chats on Iron and Steel," by L. W. Spring
MICROPHOTOGRAPH OF GRAY CAST-IRON
The crooked black lines are graphite flakes

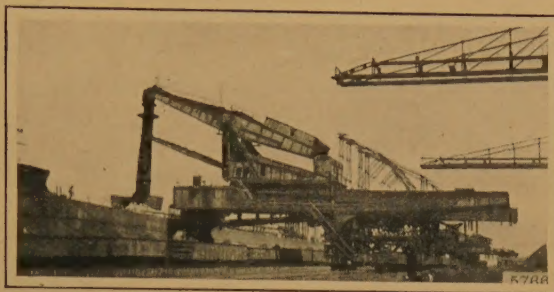
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Courtesy U. S. Bureau of Mines

HULETT UNLOADER

unloading an ore vessel on the Great Lakes. Note the operator's head in the circular opening just above the open "grab-bucket," which is descending into a hatch



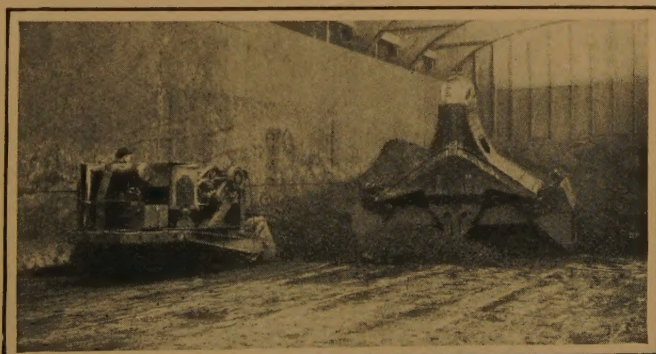
HULETT UNLOADERS AT WORK

generally hard, and most of it is mined underground in ordinary shaft mines, like the typical coal mine. On the Mesabi Range prodigal Nature has spread an enormous layer of ore, one of the largest deposits of iron known in the world, so close to the surface of the ground that shaft mining is for the most part unnecessary. Moreover, the ore is soft, like sand or clay. Hence most of the mining in this region is done with a steamshovel, and a mine is simply a huge hole in the ground. First the surface earth is stripped off, loaded into cars and carried away to the dump heaps. The amount of earth thus

removed since the range was opened in 1892 is considerably greater than the total amount excavated in building the Panama Canal. When the ore is laid bare it is scooped up by the shovels and taken out of the pit either in railway cars or by inclined hoists and conveyors. The Mesabi Range has produced more than forty million tons of ore in a year.

Transportation of the Ore

The extraction of iron from its ore requires great quantities of fuel, mainly in the form of coke, which is made from coal. There are regions, such as the famous Birmingham district of Alabama, where coal and iron are mined almost side by side, but there are no



Courtesy Brown Hoisting Machinery Co., Cleveland, Ohio.

HOLD OF ORE VESSEL

showing grab-bucket at work unloading ore. To the left is seen a gasoline-driven scraper shovel, which cleans up the ore and places it so that the bucket can get a good load each trip

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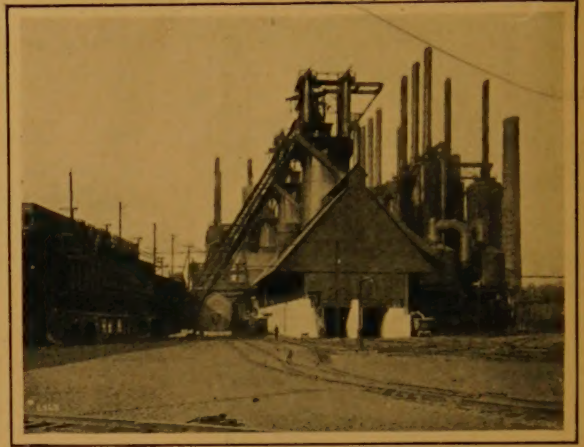
coal deposits near the Lake Superior iron mines. The ore must be carried to the coal, or the coal to the ore, or both may be taken to some intermediate point. Generally speaking, the first of these plans is found the more economical, partly because iron ore is more readily handled by machinery than coal or coke, and partly because the Upper Lake region is far from the markets where the manufactured products are to be sold. Accordingly most of the ore travels southward to the Appalachian and Illinois coalfields and the adjacent shores of Lakes Erie and Michigan. During the eight months of the year in which

the Great Lakes are open to navigation, vessels engaged in transporting iron ore file in such close formation that one is rarely out of sight of another.

First, however, the ore must be taken from the mines to the Upper Lake ports in railway cars. The most important shipping points are Duluth, Superior, Two Harbors, Escanaba, Ashland and Marquette. Before reaching the *ore-docks* the loaded cars pass over scales, where the weight of the ore is automatically registered while the cars are in motion.

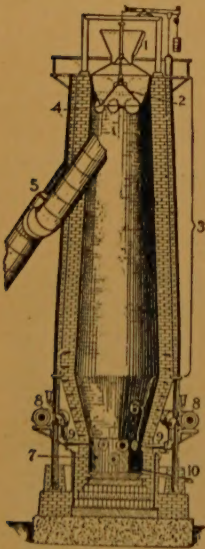
The so-called ore-docks of the Upper Lake ports are really long piers projecting out into the lake, with berths alongside for the ore freighters. Each dock is a lofty structure of timber, steel and concrete, carrying a series of pockets, or bins, into which the ore is dumped from the railway cars, which run out over the dock on elevated tracks and automatically discharge their loads. The pockets are flanked by a long row of steel chutes, hinged below, and folding up flat against the dock when not in use. The largest of these docks, at Duluth, can hold at one time 150,000 tons of ore.

The steamers that load at the ore-docks are a curiosity in shipbuilding. They are, in fact, nothing but floating steel bins, with bridge, pilot-house and officers' quarters perched up in the bow, and engines and crew's quarters far in the stern. The long intervening deck is mostly hatches, spaced twelve feet apart from center to center,



BLAST FURNACE PLANT

of the Bethlehem Steel Co., Bethlehem, Pa. Notice the stoves in rear of furnaces; also the inclined hoist by which the ore, coke and limestone are carried to the top of the furnace, into which they are automatically dumped. An average modern blast furnace produces 600 tons of pig-iron every day



One form of Blast Furnace. 1 Hopper; 2 Bell; 4 Gas Outlets to Downcomer 5; 3 Stack; 6 Boshes; 7 Hearth; 8, 8 Bustle Pipe; 9, 9 Tuyères; 10 Iron Runner

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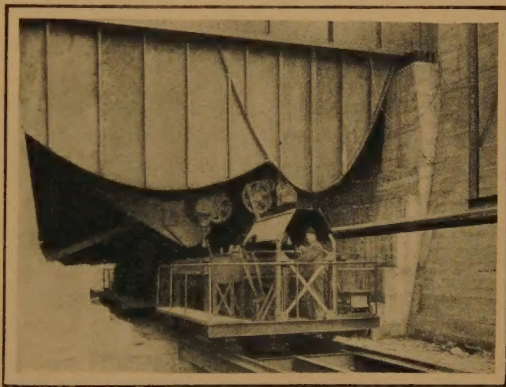
giving access to a hold that, in the biggest ships, can carry upwards of thirteen thousand tons of ore.

When a vessel comes alongside the dock the chutes attached to the ore pockets are let down into the hatches, the doors of the pockets are opened, and the ore flows into the hold so rapidly that a 10,000-ton ship has been loaded in the incredibly short time of twenty-five minutes. The ordinary time of loading for the largest ships is less than an hour. Even more astonishing, since the process is more difficult, is the speed with which the vessels are unloaded at the other end of their route—at Chicago, Gary, Ashtabula, Conneaut, Cleveland or Buffalo. Here the ore is hoisted out of the ship's hold by means of huge *grab-buckets*, which pick up from ten to fifteen tons of ore at a bite, raise it high in air, and discharge it into railway cars, or deliver it to auxiliary apparatus by which it is conveyed to cars, bins or the huge *stock pile*, in which it lies until needed. A cargo of 11,000 tons of ore has thus been taken out of a vessel in less than four hours.

Smelting

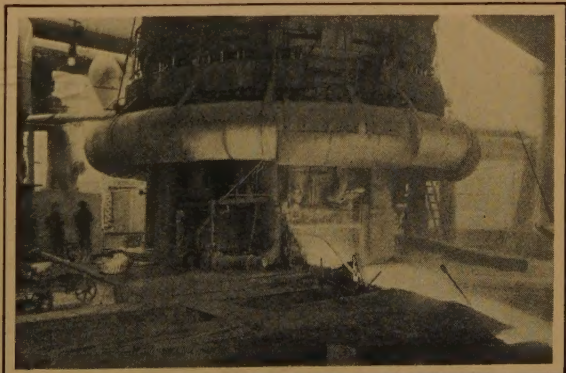
The process of extracting the iron from its ore is called *smelting*. In its essential features, it is older than civilization. Many primitive tribes have independently acquired the art of mixing iron ore with fuel, blowing up a hot blaze by means of a crude bellows or other simple device, and gathering the lumps of metal that collect in the ashes. Tradition has it that a forest fire originally revealed this art to mankind, much as a certain domestic conflagration in China is reputed to have added roast pig to the world's bill-of-fare.

The ore, as we have said, consists of iron and oxygen. In smelting, the carbon of the fuel combines with the oxygen of the ore to form a gas, which passes off, leaving a residue that is mostly iron. For many centuries iron was smelted with charcoal, but nowadays the fuel is generally coke, and another ingredient, limestone, is



WEIGHING-LARRY

passing under storage bins to receive a charge of material for the blast furnace. The exact weight of ore, coke or limestone is automatically recorded. The larry delivers the charge to the skip house, from which it is carried by the skip hoist to the top of the blast furnace



Courtesy Carnegie Steel Co.

TAPPING HOT METAL FROM THE BLAST FURNACE

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added to get rid of the *gangue*, or earthy matter mixed with the ore. With the gangue and the ash of the fuel the limestone forms the substance known as *slag* or *cinder*.

Smelting is now performed on a large scale in the *blast furnace*. This is a tower-like structure of fire-bricks, enclosed in a steel jacket, and is often a hundred feet or more in height. It is charged from the top with iron ore, coke and limestone, either by hand, or, in many establishments, by automatic machines. The contents of the furnace are kept at a fierce heat by a constant blast of air, which is furnished by powerful blowing engines and enters the furnace near its base.

The iron, as it melts, trickles to the bottom, or *hearth*, where it forms a pool upon which floats the lighter slag, also molten. There are two outlets, at different levels near the base of the furnace. The upper one, known as the *cinder-notch*, is opened at frequent intervals to draw off the liquid slag, which hardens into a dark green, glassy substance, used in making Portland cement, road-building, etc. The lower orifice, called the *tap-hole*, is opened, say, every four hours, and a glowing stream of iron flows forth.

Before we trace the history of this iron further a word must be said about a feature of the blast furnace that illustrates how, in modern industry, nothing is wasted that can be turned to account. Great volumes of combustible gas are formed in the process of smelting, and once this gas was allowed to burn uselessly as it escaped at the top of the furnace. Now it does not escape at all, but passes down through a large pipe (the *downcomer*), and part of it is used to drive



Courtesy of Oliver Iron Mining Co., Duluth, Minn.

A TYPICAL

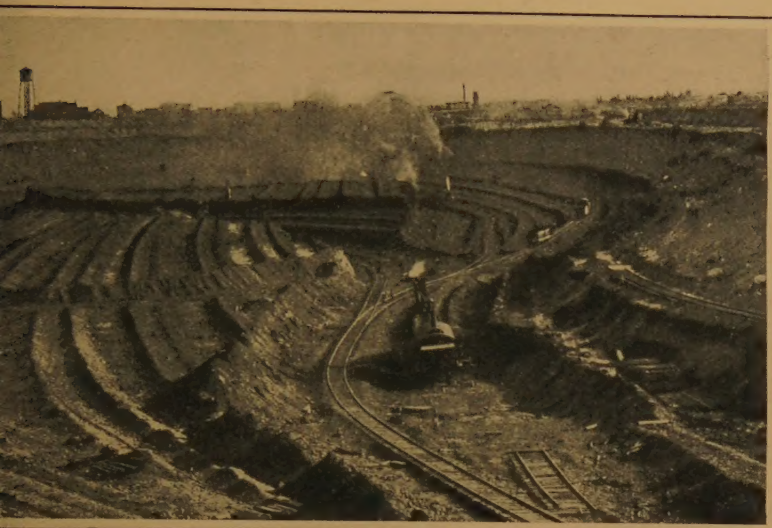


Courtesy Bethlehem Steel Co.

OPEN-HEARTH PROCESS

The charging floor, showing the electric charging machine putting material into one of the furnaces

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IRON MINE

the gas engines or to heat the boilers of the plant. The rest is used in heating the air blast of the furnace. This process is effected in the tall cylindrical structures which may be seen close to every blast furnace, and which are known as *stoves*. The gas is burned in a stove until the checker-like brick flues of the latter are raised to a very high temperature. Then the gas is shut off, and

the air from the blowing engine is allowed to pass for a time through the hot stove on its way to the furnace. By this means a much more intense heat is produced in the furnace than would be possible with a cold air blast, and the fuel-consumption is greatly lessened. Three or four stoves are attached to each furnace; while one is delivering hot air the others are being heated.

Various Kinds of Iron

The molten iron as it comes from the blast furnace is called *pig-iron*. In old-fashioned works it flows through long channels called *sows* into molds of sand or iron laid out on the floor of the cast-house and known as *pigs*, where it is left to cool and harden. In large-scale modern practice it is carried in bucket-like *ladles*, while still molten, to the steel furnaces, or it is molded in the *pig-casting machine*. This consists of a series of metal molds carried by an endless belt under a spray or bath of water, to hasten the cooling of the iron, and finally to railway cars, into which the now solid pigs are dumped. Pig-iron is used for making cast-iron, wrought iron and steel.

Cast-iron is generally made in a *cupola*, constructed much like a miniature blast furnace. This is charged with pig-iron, scrap-iron and coke, and air is blown through, as in the blast furnace. The molten iron is poured into molds of sand, in which it is left to harden. Cast-iron takes the shape of the mold better than other kinds of iron and steel, as it is very fluid when melted and expands in solidifying. On account of the large amount of carbon it contains (3 or 4 per cent.) it is generally quite brittle, and cannot be hammered into various shapes,



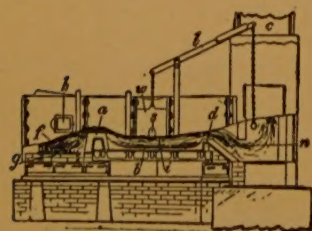
Courtesy Carnegie Steel Co.

OPEN-HEARTH FURNACES
Filling ingot molds

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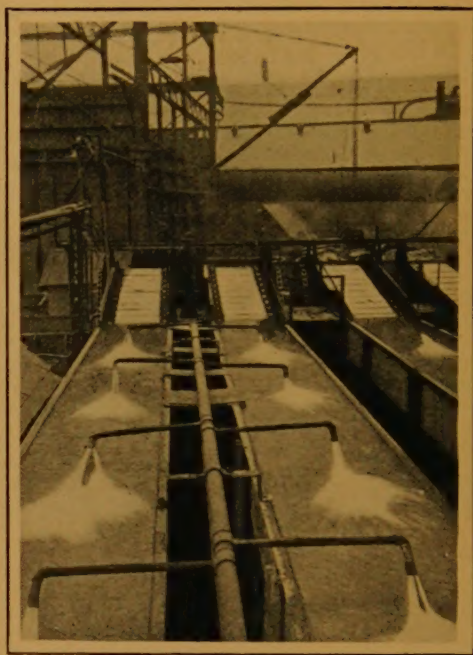
or, in technical language, it is not "malleable." There are, however, many kinds of cast-iron, differing in brittleness, hardness, etc., and some kinds can be made malleable by suitable heat treatment.

Wrought iron differs in composition from cast-iron in containing very little carbon (0.3 per cent. or less) and a considerable amount of slag. It is malleable, easily welded, and more durable for some purposes than steel, and was once the ordinary material for nails, wire, plates, bars, beams, rails, hoops, etc. Nowadays it has been displaced to a great extent by steel, on account of the large amount of hand labor required in making it. Wrought iron is made in the *puddling furnace*. The fuel—coal, or sometimes gas—is burned in a chamber separated by a low wall from the adjacent hearth, on which is placed pig-iron, resting on a layer of iron oxide in the form of iron ore or *mill scale* (the crust that forms on hot steel in the rolling-mill). The flame, passing over the wall, beats down on the iron, which is melted. A workman, standing at the door of the furnace, stirs or *puddles* the melting iron and oxide with a long iron bar, called a *rabble*. After half an hour or so the iron begins to form in little pasty grains, which the puddler molds with his *rabble* into large balls, weighing 80 to 100 pounds. These balls are taken one at a time from the furnace, squeezed by machinery to remove most of the slag, rolled into bars, cut in pieces, re-heated, re-rolled, etc., to produce a compact product with a minimum of slag. Puddling is



PUDDLING-FURNACE SHOWN
IN PARTIAL CROSS-SECTION

At the bottom of the fire-chamber (f) are the grate bars (g), the fuel being supplied at the firing-hole (h). The flames pass over the fire-bridge (a) to the iron-chamber (i) which has a bed (b), and over the flue bridge (d) through the neck (n) to the chimney (c). The lever (l) operates the working-door (w), which is used for charging with pig and removing the puddled balls, while the stopper-hole (s) serves for the introduction of the rabble



Copyright, Underwood & Underwood

COOLING FRESHLY MADE PIG-IRON

The pig-iron is taken from the places where the molten metal is poured into the molds of the pig-casting machine, and passed through cooling troughs which are constantly being replenished with cold water in the manner shown above

a conspicuous example of a tedious industrial process in which machinery has not yet replaced hand labor.

"Steel" is a word of many meanings. Our grandfathers applied this term only to a kind of iron that could be made very hard and brittle by plunging into cold water (*quenching*) when red-hot, and then made less brittle by re-heating to a moderately high temperature—a process called *tempering*. In order to have these qualities steel must contain more carbon than wrought iron and considerably less than ordinary cast-iron (say from 0.6 to 1.5 per cent.). Our modern tools and cutlery of the better grades are made of this kind of steel, but the so-called steel now used on an enormous scale for bridges, buildings, ships, etc., contains very little carbon and cannot be hardened and tempered. It is known as *mild steel*, and is essentially a slagless wrought iron.

Steels whose properties depend chiefly upon the percentage of carbon they contain are classed as *carbon steels*. There are also many important kinds of steel, known as *special steels*, or *alloy steels*, which owe their varied and valuable properties to the presence of definite amounts of substances other than carbon. These

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include manganese steel, nickel steel, chrome steel, tungsten steel, etc., each of which is appropriate for certain uses on account of its hardness, softness, toughness, elasticity, or some other quality.

Steel-Making Processes

An old and once universal process of making steel, known as the *cementation process*, consists in packing bars of wrought iron in charcoal and heating them for several days. The iron absorbs the charcoal (carbon) without melting, and acquires the hardening property once regarded as the distinctive feature of steel. From the blis-



THE WELLMAN HIGH TYPE OPEN-HEARTH FURNACE CHARGER

ters that form on its surface it gets the name of *blister steel*. The outer layers of a bar thus treated absorb more carbon than the interior. In order to get a steel of more uniform quality the bars of blister steel may be cut in pieces, which are then piled together, reheated, hammered, rolled, etc., to produce what is called *shear steel*. A better plan is to melt pieces of blister steel in crucibles of clay or graphite, which are placed in a furnace burning gas, coal or coke. As in other modern steel-making processes, the molten metal is finally poured into molds and hardens into blocks known as *ingots*. Steel made by this process is called *crucible steel*, and ingots of it are rolled into bars and used for making high-grade tools. A somewhat inferior quality of tool steel is made by melting in crucibles bars of wrought iron or mild steel, mixed with charcoal, instead of using blister steel, as above described.

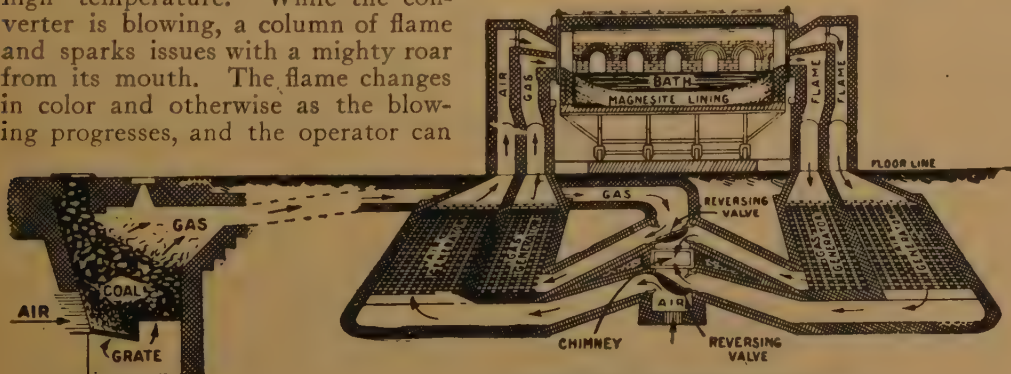


BESSEMER CONVERTER

a, mouth, with portion of side removed to show interior formation; b, blowpipe; c, trunnion; d, air-inlet pipe

In the middle of the last century Henry Bessemer in England and William Kelly in the United States invented, independently of each other, a process that revolutionized the art of steel-making. It is now

called by the name of the English inventor. In the Bessemer process molten pig-iron is charged into a large egg-shaped steel vessel, mounted on trunnions, called a *converter*. The carbon and other impurities in the iron are then burned out by sending a powerful blast of air through or over the molten metal. The combustion of the impurities in the iron suffices, without the use of any external heat, to raise the metal to a very high temperature. While the converter is blowing, a column of flame and sparks issues with a mighty roar from its mouth. The flame changes in color and otherwise as the blowing progresses, and the operator can



GAS PRODUCER

FURNACE AND REGENERATIVE SYSTEM

From "Non-technical Chats on Iron and Steel" by L. W. Spring

EARLY TYPE OF GAS PRODUCER, REGENERATORS, AND OPEN-HEARTH FURNACE

Course taken by air, gas, and products of combustion are plainly shown, as are the valves that reverse direction of flow

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tell from its appearance when the process of purification is complete. When almost perfectly pure iron has thus been produced, measured amounts of carbon and manganese are added, in order to give the steel just the qualities desired. The converter is then tilted and the metal is poured into what is called in the steel-mill a "ladle" but which looks to the layman more like a huge cauldron. From this it is poured into ingot-molds, standing on railway trucks, which take the ingots to the *stripper*, where the molds are lifted off. The white-hot ingots, each weighing about two tons, are finally lowered into so-called *soaking-pits*, which, despite their name, contain no liquid. These pits are heated by gas, and the ingots remain in them until they acquire uniform temperature and solidity. They are then ready for the rolling-mill.

About ten years after the introduction of Bessemer steel a new method of steel-making came into vogue, known as the *open-hearth* or *Siemens-Martin process*. About three-fourths of the steel now produced in the United States is made by this process. The open-hearth furnace is much like an enlarged puddling-furnace, but is heated in a peculiar manner. Below the level of the furnace are two pairs of chambers filled with brick checkerwork and known as *regenerators*. Gas and air are drawn through one pair of regenerators on their way to the furnace; the gas burns over the hearth, and the flame passes down into the other pair of regenerators, which it raises to a high temperature. The streams of gas and air are then diverted so as to pass through the heated chambers, while the flame passes into the first pair of regenerators, which it heats in their turn; this process being reversed every fifteen minutes or half hour. Thus while one pair of chambers is giving out heat the other is storing it up. The principle is much the same as that of the stoves attached to the blast furnace, already described.

The open-hearth furnace is charged with molten pig-iron, scrap steel, iron ore, and a little limestone or fluor-spar. Another important ingredient is the lining of the hearth, which is of different materials according to the particular impurities that need

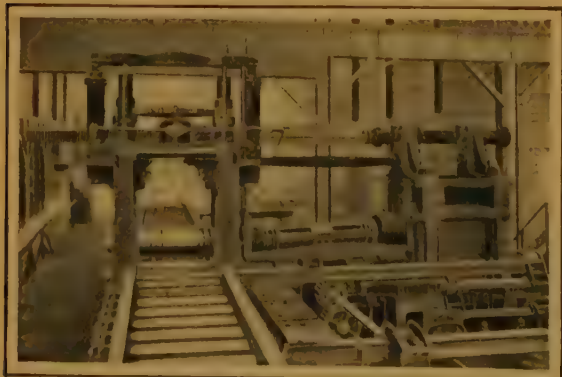
to be removed. While in the Bessemer converter the steel is made in a few minutes, in the open-hearth process the materials remain in the furnace from six to twelve hours, but a far larger amount of steel is produced at one time—seventy to a hundred tons in the larger furnaces. At the end of the *heat* the molten steel is drawn off into a ladle, poured into ingot-molds, and otherwise treated the same as Bessemer steel.

In the newest method of making steel an *electric furnace* is used; in other words, a furnace heated by electricity instead of by fuel. All



Courtesy of Pittsburgh Furnace Co.

THREE-TON PITTSBURGH ELECTRIC FURNACE
Maynard Steel Foundry Co



Courtesy of Mackintosh, Hemphill & Co.

ROLLING MILL AT WORKS OF LACKAWANNA STEEL CO.
BUFFALO, N. Y.

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kinds of steel can be made by this process, but the product is too expensive to compete with the common grades of open-hearth and Bessemer steel. High-grade steels are being more and more generally made by the electric process, which is thus rapidly displacing the crucible process. Both the temperatures and the chemical reactions involved in steel-making can be much more perfectly controlled by this process than by any of the older methods. The electric furnace is now often used for improving or "super-refining" Bessemer or open-hearth steel, and for making steel castings.

The Final Operations

in the steel-mill consist of rolling, forging and sometimes drawing. The white-hot ingots, when taken from the soaking-pits, are placed on a long train of rollers which carry them along to the heavy rolls of the *cogging-mill* or *blooming-mill*, between which the ingot passes as wet clothes pass through a wringer. Then the rolls are set a little closer together, the mechanism is reversed, and the ingot passes through in the opposite direction; this process being repeated several times. An elongated block of metal is thus produced, which can be further rolled into a variety of finished products, such as rails, beams and plates, or into blocks of different shapes and sizes, known as *billets*, *blooms*, *slabs*, *bars*, etc., destined to be used, at the original plant or elsewhere, for forging, wire-drawing, and the manufacture of innumerable articles of steel.

Iron and steel are *forged* by hammering, either by hand or machinery; also by pressing with an hydraulic press. Forging is a much slower process than rolling, but is capable of producing a much greater variety of shapes.

Drawing is the process used in making wire. In this process metal rods are drawn through holes of successively smaller diameter until of the desired fineness. Unlike rolling and forging, the drawing of wire is done cold.



Courtesy of the U. S. Bureau of Mines

CUTTING HEAVY STEEL SLABS

Homestead Works of The Carnegie Steel Co.



Courtesy Bethlehem Steel Co.

STOCKYARD SHOWING STRUCTURAL STEEL BEAMS

SUPPLEMENTARY READING

NON-TECHNICAL CHATS ON IRON AND STEEL

By LaVerne W. Spring

THE STORY OF STEEL By Donald Wilhelm
Published by the U. S. Steel Corporation.

THE ROMANCE OF STEEL

By H. N. Casson

THE METALLURGY OF IRON AND STEEL
2d ed., 1911

By Bradley Stoughton

THE A B C OF IRON AND STEEL, 2d ed., 1917

By A. O. Backert

See also Encyclopaedia Britannica and New International Encyclopaedia, under "Iron and Steel."

T H E O P E N L E T T E R

On January 3rd last died Winfield Scott Potter, in age actually fifty-two years, but in work and accomplishment, much older than that. He slept little, ate little, and played not at all during twenty years of stern, unrelenting devotion to the accomplishment of one purpose. Who was Winfield Scott Potter? In the phrase of the man of the street, he was the genius that "put the Man in Manganese Steel." We gather an interesting account of his career from *The N. Y. Sun*. Potter did not invent manganese steel. There had been for years an alloy known as "manganese steel." It was more durable than ordinary carbon or cast steel, and an ideal metal for railroad rails. But nothing could be done with it commercially because it could not be rolled. Chemists, scientists and metallurgists all over the world, recognizing the great value of manganese steel, provided it could be placed on the market, had experimented with it unsuccessfully. Sir Robert Hadfield, of Sheffield, England, one of the leading metallurgists, made some progress but did not reach the required result. Manganese steel still refused obstinately to be shaped into rails. Many expensive experiments were made and heavy losses incurred. It looked as if nothing could be done in the matter. Then Winfield Scott Potter took up the task. Mr. Potter was born in Brooklyn, and his father, Mark L. Potter, was a retired sea captain who had acquired considerable wealth. He had no faith in his son's undertaking, however, and would not advance him any money to carry on experiments, so young Potter had to go it alone. Not having the means to put up a furnace elsewhere, he built one in the cellar of the St. George Hotel, in Brooklyn. Guests still remember the smoke that used to burst suddenly from the lower quarters during the days when Potter was experimenting there. Major John W. Tumbridge, the son of the owner of the St. George Hotel, had been a classmate of Potter's in the Brooklyn Polytechnic Institute, and had opportunity to observe the struggles of the young inventor at close hand. "His devotion to that furnace," said Major Tumbridge, "and to the one he put up afterwards in Hamilton Avenue, astonished me. I have never known a case in which persistence to win out was more remarkably demonstrated. The man would not eat or sleep for days. We would go in search of him, and when we found him, he would ask us what day of the week it was. He would not know apparently how long he had been without food or when he had last been in bed. No man without his giant frame and extraordinary tenacity could have stood it."

★ ★ ★

From Hamilton Avenue, Potter, in 1907, transferred his operations to New Jersey. By working in foundries there he was able to earn enough money for his personal expenses, and at the same time, go on with his experiments. He became connected with the American Brake Shoe and Foundry Company as superintendent and chief chemist, and it was while there that he found the secret of rolling manganese steel. He discovered that, by heating steel

to a certain temperature, it could be passed through the rolls and worked into rails and other shapes, and he demonstrated this to Mr. Gallagher, a prominent officer of the American Brake Shoe and Foundry Company. He then succeeded in getting backers, and they took over an old foundry at Paterson, there to carry on additional experiments and prove the practical value of his invention. They gave demonstrations at the Braeburn Steel Company in Pennsylvania, and at works at Mahwah, New Jersey, the latter becoming the nucleus of the Manganese Steel Rail Company.

★ ★ ★

One most impressive demonstration at Mahwah, which was attended by steel manufacturers and railroad engineers from all over the country, consisted of dropping a huge steel ingot, weighing many tons, on a single bar of manganese steel laid across supports raised well off the ground. The bar was scarcely even dented. Many public tests also were carried out to show the method of heating the steel. The metal by nature was tricky and capricious until just exactly the right temperature was reached. The slightest variation either above or below the point required, destroyed its value. It would at once revert to its former brittle state and either break up or smash the rolls.

★ ★ ★

Mr. Potter's years of labor had brought their reward. The Manganese Steel Rail Company, incorporated in 1911, supplied its product to the Interborough Rapid Transit Company of New York, to the elevated lines of Chicago, the tubes in Boston, then to the New York Central, the Pennsylvania, the Lehigh Valley and other railroads. Reports were made by these various corporations on the durability of the Potter invention, and it was shown that a manganese steel rail would outwear seven ordinary carbon steel rails. Mr. Potter was making guns for the British government when his factory was taken over by the United States government soon after the country entered the war. His process has been introduced into England and other countries.

★ ★ ★

But the years of devoted labor took their toll. Potter had never spared himself, and the price that he paid in brain, nerve and muscle had begun to drain his vitality. "It became necessary," said Mrs. Potter, "for my husband to be at the works constantly while the heating process was going on. He would remain there hour after hour, and sometimes day after day, so that when he started for home he would stagger from exhaustion and people would think he had been drinking." Mr. Potter had taken out a large number of patents and was making elaborate plans for marketing them, when he became ill in Pittsburgh. It was a complete breakdown. He was removed to the Western Pennsylvania Hospital and died there. Such is the story of the man that perfected Manganese steel.

W. S. Moffat
EDITOR

THE STORY OF IRON AND STEEL

Iron and Steel in the United States

ONE



ALTHOUGH the American Indians, before the arrival of the white man, often cut implements and ornaments from the harder kinds of iron ore and occasionally shaped such articles from the native iron found in meteorites, they never acquired the art of smelting. Deposits of iron ore were found by the early European settlers,

and as early as 1619 a party of workmen sent out from England by the Virginia Company began the manufacture of iron at Falling Creek, near Jamestown, Va. The production and export of bar iron and pig iron had already gained considerable importance before the Revolutionary War. It was not, however, until after the close of the Civil War that the United States became one of the great iron-producing countries of the globe. At the present day our country occupies the first place in this industry and is the source of half the iron and steel produced in the world.

Of the iron ore mined in the United States, about 85 per cent. comes from the Lake Superior district of northern Minnesota, Wisconsin and Michigan, and about 8 per cent. from the Birmingham district of Alabama. Iron-mining regions of less importance include a district near Chattanooga, Tennessee, the Adirondack region of New York, and an area in northern New Jersey and southeastern New York. Minor deposits are scattered over more than a score of states.

There are three methods of mining iron. The most productive mines in the world—those of the Mesabi Range, in Minnesota—are huge open pits, terraced down the sides, in which the ore is dug out with steam-shovels, aided by blasting. Elsewhere in the Lake Superior region shaft mines are common, some of them going as deep as 3,000 feet underground. A third method of mining iron is called "milling." A bed of ore is first stripped of overlying earth and rock, as in open-pit mining; then tunnels are driven underneath the ore, and shafts are driven down from above

to the tunnels. Finally, the ore is quarried from the walls of the shafts and allowed to pour down into railway cars in the tunnels.

In the manufacture of iron and steel, Pennsylvania has always held first rank among the states of the Union, the chief stronghold of the industry being the district about the city of Pittsburgh. Another important seat of the industry has its center at Chicago, which enjoys direct water communication with the Upper Lake ore ports and unrivaled railway facilities for distributing the finished products. In this vicinity are made most of the rails used on western railways. Not far from Chicago is the unique industrial town of Gary, Indiana, on the shore of Lake Michigan, founded in the year 1906 by the Indiana Steel Company (now the Illinois Steel Company, and a subsidiary of the United States Steel Corporation). It is said to be the greatest steel-producing town in the world.

Many important iron and steel works are situated in Ohio, western New York, eastern Pennsylvania, Maryland, Tennessee and Alabama. Comparatively little iron and steel is made west of the Mississippi River.

Statistics of this industry of course vary widely from year to year. The latest figures may be obtained from an annual publication of the United States Geological Survey, in Washington, entitled "Mineral Resources of the United States." The section devoted to iron and steel can be had in separate pamphlet form.

The amount of iron and steel manufactured each year in the United States is at the rate of about 900 pounds for every man, woman and child in the country.



THE STORY OF IRON AND STEEL

Machinery for Handling Iron and Steel

TWO

MODERN civilization is founded upon the work of machinery, as ancient civilization was upon that of slaves. It has been estimated that all the machinery in the United States, not counting that driven by the muscles of human beings or the lower animals, utilizes as much energy as could be derived from three billion slaves.

In other words, every man, woman and child in the country has at his disposal the equivalent of thirty hard-working servitors.

The machines employed in the iron and steel industry perform feats akin to those ascribed to the genii of Eastern legend. It is a remarkable fact that the iron used in making many important articles of steel, such as rails for railways, beams for buildings and bridges, and plates for ships and boilers, is never touched by a human hand or lifted by human muscles from the time the ore is scooped from the ground in Minnesota to the time the finished product emerges from the rolling-mill, a thousand miles from the mine.

Day and night the huge steam-shovels toil in the pits of the ore range, filling railway cars with ore. A fifty-ton car is loaded in five minutes. Then the trains of fifty cars or more are drawn by Mallet locomotives (the monsters with two cylinders and two sets of driving-wheels on each side) to the ore docks at Duluth or Two Harbors, or elsewhere on Lake Superior. Within the memory of men now living ordinary shovels and wheelbarrows were used to take the ore from the mine and to load it on board vessels. The way in which the latter process is now performed is described in our main text. Mechanical methods of unloading the ore at the Lower Lake ports have all been developed since the year 1880. Thanks to labor-saving machinery, iron ore can be carried from the Lake Superior ports to the Lake Erie blast furnaces at a cost of only \$.0007 per ton per mile. As soon as an ore boat is unloaded she immediately coals, whole car-loads of fuel being dumped into chutes leading to her bunkers by the car-dumper (described and pictured in the Mentor number, "The Story of Coal"), and starts up the Lakes for another load. The

round trip, including loading and unloading, requires only seven days.

The grab-bucket used in the unloading and subsequent handling of ore scoops up this material as your two hands scoop up sand or sugar. The two jaws of the bucket close with a scraping motion, taking as much as fifteen tons at a bite. When the bucket has been swung to the place where it is to be discharged the slacking of a cable permits the jaws to open and dump their load.

Probably the most interesting mechanical device used in handling iron and steel is the lifting-magnet. This is a form of crane in which the lifting is done by an electro-magnet. The very largest of these cranes will lift a mass of metal weighing twenty-five tons. The lifting-magnet is now commonly used for loading and unloading pig-iron and scrap-iron and steel, as well as for many other purposes. It is an uncanny sight to see half a dozen kegs of nails swung aloft, held firmly to the crane by the mysterious force of magnetism, in spite of the wooden barrier between the magnet and its load. Owing to the powerful attraction it exerts upon every particle of iron or steel in its vicinity, the lifting-magnet makes an excellent broom for sweeping up small scraps and dust of the metal.

One form of lifting-magnet is used for picking up what is called the "skull-cracker ball," weighing ten tons, and dropping it upon a quantity of imperfect metal that is to be broken up for remelting. Magnets are also used in shipbuilding for holding sheets of iron or steel in position while being riveted.

Our gravure shows one of these cranes unloading scrap steel. The process requires two hours per car, while it takes eight men ten hours to unload a car by hand.



THE STORY OF IRON AND STEEL *The Blast Furnace*

THREE

THE earliest blast furnace was probably a hole in the ground, in which a wood fire was blown to a brisk blaze either by the breath of the smith or by the winds of heaven. Bits of ore, mixed with the fuel, were thus slowly made to yield a meager supply of iron. In the course of time the process was improved by the addition

of a bellows. Many centuries later the bellows was harnessed to a water-wheel, and the stronger draft thus produced made it possible to treat a longer column of ore and fuel at one time. Meanwhile the furnace had assumed the form of a stone or brick chimney, the shape of which is expressed in the modern French name for the blast furnace—*haut-fourneau*, "high furnace."

Until quite recent times the fuel commonly used in the blast furnace was charcoal. In England the increasing scarcity of wood in the seventeenth century led to experiments in the use of mineral coal and coke, but it was not until the following century that coke became the standard fuel for smelting. On account of its porous structure it burns more rapidly than coal, and as it is stronger than charcoal it will support a heavier load in the furnace, which may therefore be built to a great height, with a corresponding increase in output. Both charcoal and mineral coal are, however, still used to a limited extent in smelting iron. Charcoal pig-iron, made in the Lake Superior region, commands a somewhat higher price than coke iron, from which it differs slightly in composition.

A modern blast furnace is from 90 to 100 feet in height and produces upwards of 600 tons of pig-iron a day. As ore from Lake Superior can be brought down only during the season of navigation, a large accumulation, or "stock pile," for use through the winter, forms a conspicuous feature of many American blast-furnace plants. Traveling buckets, suspended from steel bridges, pick up the ore from the pile and carry it to the side of the furnace, where different grades of ore, as determined by

chemical analysis, are placed in separate bins. Coke and limestone are likewise stored in bins near the furnace. Carefully measured amounts of these materials are charged into the furnace from time to time, so as to keep it always nearly full. Coke is charged first, followed by ore (a definite mixture of the different grades) and limestone. Sometimes the material is shoveled into the furnace by workmen stationed at the top, but in many establishments the charging is done by machinery, the material being carried up an inclined track to the top of the furnace in a large bucket, which discharges its load into the furnace. The top of the latter is closed by two bell-shaped covers, one above the other, so arranged that when one is open the other is shut, and the escape of gas from the furnace is thus prevented. Thus a single engineer, in charge of the hoisting apparatus, can keep the furnace supplied with material at the rate of 1,700 tons a day.

A tremendous blast of hot air is constantly driven through the furnace by a blowing engine. A large furnace requires as much as 37,000 cubic feet of air a minute.

At intervals of a few hours the molten iron is drawn from the "tap hole" at the base of the furnace, either to be cast into "pigs," or for use in the molten form in making steel. The plug of clay which closes the tap-hole was formerly removed by breaking it with a long steel bar, welded by several men, but this once laborious occupation is now easily performed by a power-driven drill. After tapping, the hole is again rammed full of clay by means of a device called a "gun."



ROBERT H. & BIRCHALL OF NEW

ROBERT H. & BIRCHALL OF NEW



ABOUT sixty years ago a new kind of steel made its appearance in the world. Just as the old-fashioned steel, still used in making tools and cutlery, differs from cast-iron in containing less carbon, so the new kind of steel differs from the old in containing a still smaller percentage of carbon, while it differs from wrought iron in

lacking the admixture of slag which gives to wrought iron its fibrous structure. This younger member of the steel family, known as "mild" or "low-carbon" steel, cannot be hardened and tempered, as tool steel can, but it is strong, soft, free from brittleness, and easily cut or bent into any desired shape. Therefore it is admirably adapted for use in making railway rails, beams for bridges and buildings, plates for ships, and an immense variety of other structural elements and useful articles that were once universally made of wrought iron. The invention of the Bessemer process, and subsequently of the open-hearth process, made the production of low-carbon steel so cheap and easy that it has quite generally displaced wrought iron, except for a few special purposes. About 99 per cent. of the steel now made in the United States is of the low-carbon variety. It is rather unfortunate that this material was given the name of "steel," for it is as distinct a product of iron as cast-iron, wrought iron or tool steel.

The Bessemer process is sometimes called the "pneumatic" process, because its distinctive feature consists of blowing air through a mass of molten pig-iron, until the carbon and other impurities in the iron are almost entirely burned out. These impurities themselves constitute the fuel which, combined with the oxygen of the blast, keeps the metal at a very high temperature until the process is complete.

Many great inventions and discoveries have been made simultaneously by two or more persons. The pneumatic process of making steel was invented about the same time by William Kelly, of Eddyville, Kentucky, and by Henry (afterward Sir Henry) Bessemer in England, but Bessemer was the first to make it a commercial success. It is a satisfaction to know that both men reaped financial profit from the invention, though, while Bessemer made about ten million dollars out of it, Kelly made only half a million.

In the Bessemer process the molten pig-iron from the blast furnaces is first carried in huge ladles to the "mixer," a vessel which holds and keeps hot from 75 to 300 tons or more of metal. The mixer was invented by W. R. Jones, an American. Its purpose is to provide iron of uniform composition for use in the Bessemer converter, by mixing the metal from several blast furnaces and treating it, if necessary, to give it the desired composition.

The spectacular process of "blowing" in the big egg-shaped converters, each holding some fifteen tons of metal, is thus described by Mr. L. W. Spring, in his "Non-technical Chats on Iron and Steel":

"One sees a little 'dinky' engine come shooting into the converter building with its ladle of molten iron from the 'mixer.' With America's time-saving routine not a single minute is lost while emptying the metal into the converter, now in a horizontal position. Almost before the ladle is out of the way, the converter swings to the upright position with the blast already on. Reddish-brown smoke and a shower of sparks come from the converter. These gradually develop into a flame. After from three to five minutes half of the silicon and manganese have been burned out. If the temperature of the metal and other conditions have become right the carbon then begins to burn. This gives a change in the nature of the flame, which becomes large and of a dazzling whiteness. An experienced blower can judge through every period of the operation of the condition of his metal and just how things are progressing. After some minutes the flame begins to waver and later 'drops', i.e., there is scarcely a flame at all."

This is the signal to lower the converter in order to add a small charge of molten "spiegeleisen," containing just enough carbon, manganese and silicon to give the steel the right qualities. Lastly the molten steel is poured into a ladle, and from the ladle into ingot molds.



COURTESY BETHLEHEM STEEL CO., BETHLEHEM, PA

BESSEMER CONVERTER BLOWING

THE STORY OF IRON AND STEEL *Open-Hearth Steel*

FIVE

THE Bessemer process makes steel in comparatively small lots or "heats" very rapidly. The open-hearth process makes it in large lots much more slowly. Both are vastly cheaper than the old-fashioned methods of making steel, but the open-hearth method, though less prolific than the Bessemer, is able to use

a wider variety of raw materials, is more easily controlled, and, on the whole, has proved so economical that it has become the leading steel-making process. Nearly three times as much open-hearth steel is now made in this country as Bessemer steel.

The open-hearth process is by no means so interesting to watch as the Bessemer. There is no blowing of air through the metal, which is merely heated and kept molten for several hours in a broad shallow furnace. This furnace, which burns gas and is provided with an ingenious device for conserving heat, as described in our main text, was invented by Sir William Siemens about 1860, and was first applied to steel-making by the Martin brothers, in France, in 1864. Hence the open-hearth process is often known as the Siemens-Martin process.

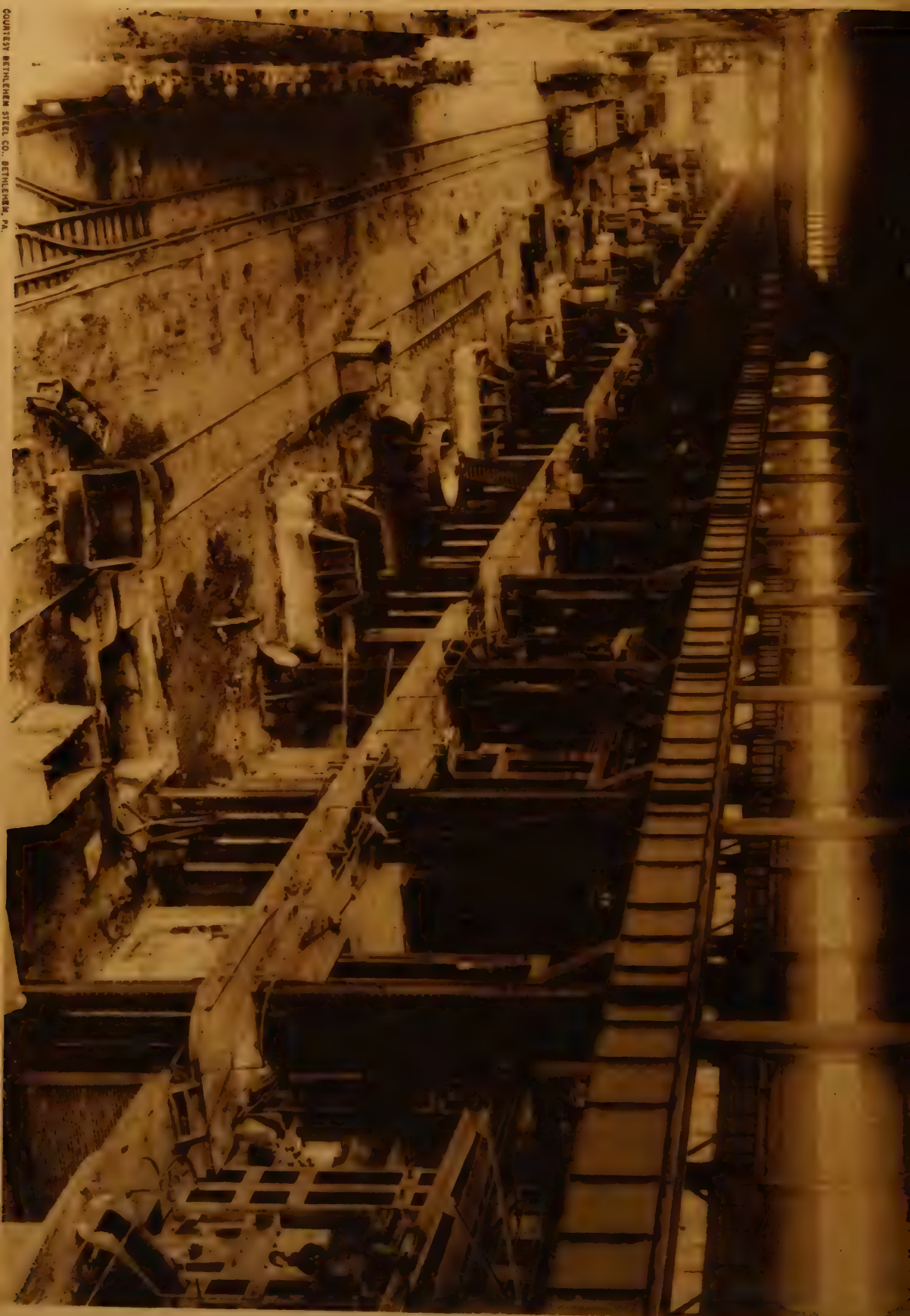
There are several varieties of this process, calling for different kinds and proportions of material. At a typical American plant the principal charge consists of equal amounts of pig-iron and steel "scrap." The scrap is first broken into bits under the blows of a heavy ball, raised by a powerful magnet. It is brought to the furnace in iron boxes, loaded on small cars. One box after another is lifted by an electrical charging machine, pushed through the furnace door, and inverted to discharge its contents. Then the molten pig-iron is brought from the mixer, as in the Bessemer process, in great bucket-shaped ladles, handled by an overhead crane, and this metal is poured into the furnace. Small quantities of limestone and iron ore complete the charge, while the lining of the

furnace itself contributes to the chemical reactions that purify the steel. Spiegeleisen or some other material for adding carbon, etc., is introduced at the end of the process.

Open-hearth furnaces are charged from the front and tapped at the rear. Our gravure shows the rear, or tapping side, of a long row of such furnaces. When the charge is ready for tapping, a ladle is placed in position by an overhead crane. A gas flame is kept burning in the ladle while it waits for its load in order that its surface may be perfectly dry. A few drops of water under the molten steel would cause a disastrous explosion. When the plug of clay which closes the tap-hole of the furnace has been rammed out with a steel bar, the fiery flood of steel gushes forth into the ladle. The molten slag, which covered the bath, comes last and often overflows the sides of the ladle. Finally the ladle is swung by the crane over a row of ingot-molds, standing ready on cars, and into these the metal is poured (in technical language, "teemed"). The further history of the steel is traced in Monograph No. 6.

In the gravure several ingot-molds will be seen at the left of the picture, while about midway of the row of furnaces a stream of molten steel is seen running into a ladle.

There are other types of open-hearth furnace besides the one just described. Sometimes the body of the furnace is mounted on rollers so that it may be tilted for tapping, and the tilting furnace can be so arranged as to pour directly into the ingot-molds, dispensing with the ladle.



COURTESY BETHLEHEM STEEL CO., BETHLEHEM, PA.

IN the preceding monographs we have seen how the molten steel from the Bessemer converter and the open-hearth furnace finds its way to the ingot-mold; also the usual destination of steel made in the crucible or the electric furnace. A certain amount of steel is, indeed, poured directly into molds shaped for pro-

ducing various finished articles of "cast steel," but a much larger part of the total product first assumes solid form as an ingot, and the subsequent steps in its manufacture into useful articles consist of forging, rolling, pressing, and so forth.

Ingot-molds are usually of cast-iron, and taper slightly toward the top to facilitate removal from the ingot. The molten steel is tapped from the big bucket-shaped ladle through a hole in the bottom into molds standing on small cars or "buggies," which are then hauled away to the "stripper," where an overhead mechanism lifts the molds from the white-hot ingots. The ordinary weight of a Bessemer or open-hearth ingot is from two to ten tons, while ingots weighing as much as 100 tons are made for special purposes, such as armor plate.

When the ingot is stripped of its mold it has hardened at the surface, but its interior is still soft. In this condition it is not suitable for rolling, and it is therefore placed for a time in a gas-fired pit, known as the "soaking-pit," where its interior cools and solidifies while its exterior is reheated. The upper part of the ingot generally contains cavities and other defects, and is therefore cut off at some stage in the rolling process, and goes back to the furnace to be remelted.

The ingot is lifted from the soaking-pit by a crane and placed upon the so-called "table" of a rolling mill. The table is a long train of rollers, which carry the ingot forward to a pair of huge rolls, through which it passes and is thus squeezed into a thinner and longer block. By further passes between rolls of various shapes and

sizes it is transformed into elongated or flattened pieces of steel known as "blooms," "billets," "slabs," "bars," "plates" and "sheets," or into articles of less simple form, such as railway rails, I-beams, channels, angles, and so forth.

The rolling of ingots into steel rails is thus described by H. N. Casson in his fascinating book, "The Romance of Steel":

"Back and forward they plunge through the rolls, which are operated very much as is the wringer of a laundry. Every time an ingot goes between the rolls it becomes longer and thinner. Soon it looks like a flaming red worm, twisting and squirming to escape. Sparks flash from it as it writhes and springs savagely at the rolls. You notice that it is now a rail.

"In a second it is switched to another track, and springs away as if it had succeeded in escaping from its tormentors. Two whirling saws cut off its ends, with a sudden shriek and blaze of fireworks. Steel hands grip it again and fling it through a cold rolling-machine, so that its surface may be hardened. Nothing now remains except to straighten it and drill holes in the ends. Its agony is ended.

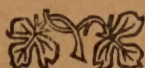
"No human hand has touched it, from beginning to end. The only hand labor is the drilling of the holes."

And so of almost every step in the process of making iron and steel we may repeat those words which mean so much for the welfare of mankind: "No human hand has touched it." We have become a race of slaveholders, but our slaves have no muscles to grow weary and no nerves to revolt against drudgery.



COURTESY BETHLEHEM STEEL CO. BETHLEHEM, PA.

TWO GREAT IRONMASTERS



IN the Story of Steel two names loom large—Bessemer and Carnegie. These two great Captains of Industry led the world in the manufacture of steel. They made steel so successfully that it turned into gold under their hands. Out of base metal they forged vast fortunes for themselves and their associates. Andrew Carnegie made more out of steel than any other man in the history of the world. He began life with nothing but a few personal assets—shrewd intelligence, industry and ambition. After fifty years of constructive work, he cashed in material assets to the amount of half a billion dollars. Andrew Carnegie retired from active work in 1901, but his name goes on, for the Carnegie Men are the Steel Masters of today. Set against a background of humble circumstances in boyhood, the phenomenal success of Andrew Carnegie places his figure in high relief. He was thirteen years of age when his father emigrated from Scotland to America and settled in Allegheny, Pennsylvania. Young Andrew began as a bobbin-boy in a cotton factory; then, in a few years, became telegraph clerk and operator. Mr. T. A. Scott, of the Pennsylvania Railroad, picked him out and employed him as a secretary. That was the beginning of Carnegie's progress, for, as Scott advanced in office, Carnegie accompanied him, and, in a few years, he was superintendent of the Western Division of the Pennsylvania Lines. The first source of his enormous wealth came through his interest in sleeping-car manufacture. He made money rapidly and invested it shrewdly. He realized a large profit in oil wells. Then, foreseeing the demand that would grow in America for iron and steel, he entered that industry, and during the rapid advance of the iron and steel industry in America, he was always two or three steps ahead of the game. He started the Keystone Bridge Works, built the Edgar Thomson steel-rail mill, bought out the rival Homestead Steel Works, and, by 1888, he controlled an enormous plant served by tributary coal and iron fields, a railway 425 miles long, and a line of lake steamships. When he retired from the steel industry, his fortune was so vast that it has required the service of many busy organizations simply to give part of it away.



It is Sir Henry Bessemer that we have to thank for safe and speedy travel on railroads today. Before Bessemer's time iron was used for rails, and iron gave way under service. Iron rails spread and split, and high speed on them was impractical. Henry Bessemer was born in 1813 in Hertfordshire, England, and early in his business career his attention was drawn to the problem of improving the manufacture of steel. If better guns were to be made and better rails were to be laid, better metal must be obtained. Bessemer's great invention was a converter for changing pig-iron into steel. The process has been described by Mr. Talman in the present number of *The Mentor*. When Bessemer announced the discovery of his converter in 1856, notice was taken of it, though many people doubted the success of his method. The first attempts of ironmasters to put the process to practice were failures. After two years' experimenting, Bessemer so far improved the process that he set up a great factory in Sheffield for the purpose of turning out his kind of steel. His business grew steadily, due to the fact that he could give the same quality of steel at a price \$100 per ton less than other manufacturers. When the Bessemer method was found to stand the test successfully, Sir Henry was besieged by offers, and, before long, he was making profits on his process that amounted to a vast fortune every year. In 1879 he was made a fellow in the Royal Society and was knighted by the queen. Bessemer died in London on March 15, 1898. The name of Bessemer has stood for years for Sterling Steel.

THE MENTOR

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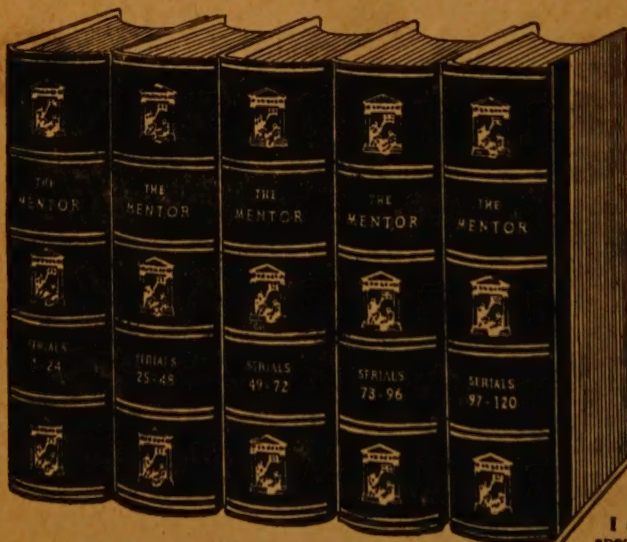
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